

# **Performance of the Wheeler North Reef**

## **2021 Monitoring Results**



**April 4, 2022**

**SONGS Mitigation Monitoring Project  
Marine Science Institute, University of California Santa Barbara**

## **Performance Standards**

*Used to evaluate whether the Wheeler North Reef compensates for loss of kelp forest habitat caused by SONGS*

- 1. Relative standards: Must be similar to natural reefs in the region**
- 2. Absolute standards: Measured against a fixed value at Wheeler North Reef only**

The goal of the Wheeler North Reef is to compensate for the loss of kelp forest habitat caused by the operations of SONGS.

- A variety of physical and biological performance standards are used to determine whether this goal is met

Two types standards are used to judge the performance of the Wheeler North Reef

- 1) Relative standards, which are measured at Wheeler North Reef and the two reference reefs and are used to evaluate whether the Wheeler North Reef is performing similar to natural reefs
- 2) Absolute standards, which are measured against fixed values at Wheeler North Reef only
  - Absolute standards are based in part on actual measured impacts to the San Onofre kelp forest resulting from SONGS operations

## Relative Performance Standards (requires comparison to natural reference reefs)

**RATIONALE:** To be successful, the Wheeler North Reef must sustain a kelp forest community that is *similar* to those of natural reefs in the region.

### Criteria for reference reef selection:

- 1) History of sustaining giant kelp
- 2) Occur at a depth similar to that of the artificial reef
- 3) Primarily low relief, preferably consisting of cobbles & boulders
- 4) Located within the local region

**The kelp forests at San Mateo and Barn best met these criteria**



- Evaluating the relative performance standards requires comparing the Wheeler North Reef to natural reference reefs in the region.
- Choosing the natural reefs that are used for reference was a critical element of the mitigation project because they form the basis for determining whether Wheeler North Reef is successful in meeting its goals
- The nearby kelp forests at San Mateo and Barn were selected as reference reefs because they:
  1. have a history of sustaining giant kelp
  2. occur at a depth similar to that of the artificial reef
  3. are primarily low relief, consisting of cobbles and boulders
  4. are located within the local region

## Relative Performance Standards

(must be similar to natural reference reefs)

**Definition of similar:** The 4-year running average for a relative performance standard at Wheeler North Reef must *not be significantly less than* that at the reference reef having the lowest value for that performance standard.

### Rationale:

- For a given relative performance standard, the Wheeler North Reef should perform at least as well as the lowest performing natural reef used as a reference
  - The biological characteristics of a reef (natural or artificial) fluctuate over time and a 4-year running average takes this variability into account when evaluating reef performance
- 
- The SONGS Coastal Development Permit envisioned a quantitative definition of “similar” for comparing the performance of the artificial reef to natural reefs, and it specified that the measure of similarity be defined in the monitoring plan for the project
  - After considerable discussion the definition for the measure of similarity that was adopted was “the 4-year running average for a performance variable at Wheeler North Reef must not be significantly less than the reference reef having the lowest value for that performance variable”
  - This definition recognizes that no two natural reefs are identical, but that any reef chosen as a reference site should serve as an acceptable standard
  - Because the biological characteristics of reefs often vary from year to year and there is a certain amount of error associated with any type of sampling, we use the 4-year running average of the performance standard to help account for this variability

## Performance Monitoring



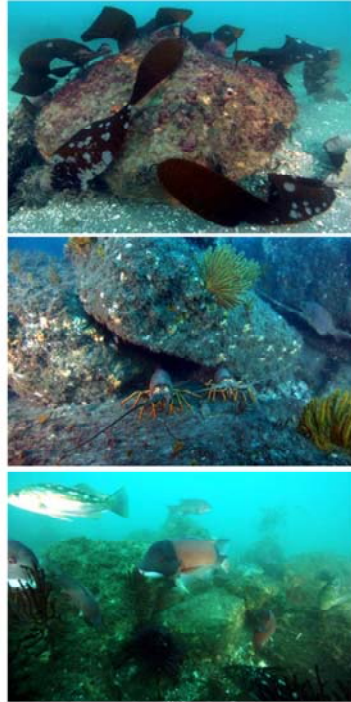
### Impacts of COVID-19

University sponsored research shutdown  
from mid March to mid July 2020

- Caused the number of Phase 1 & 2 sampling stations to be reduced from 92 (shown as black lines) to 15 (shown as yellow dots)
- Reduced sampling increased uncertainty in assessing some performance standards
- As a result, 2020 data were excluded from the 4-year running average used to evaluate many of the performance standards in 2021 (i.e., the running average for 2021 is based on data collected in 2018, 2019 and 2021 only)

## Relative Performance Standards for Wheeler North Reef

1. Algal percent cover
2. Algal species richness
3. Sessile invertebrate percent cover
4. Mobile invertebrate density
5. Invertebrate species richness
6. Resident fish density
7. Young-of-Year fish density
8. Fish species richness
9. Fish reproductive rates
10. Fish production
11. Food chain support

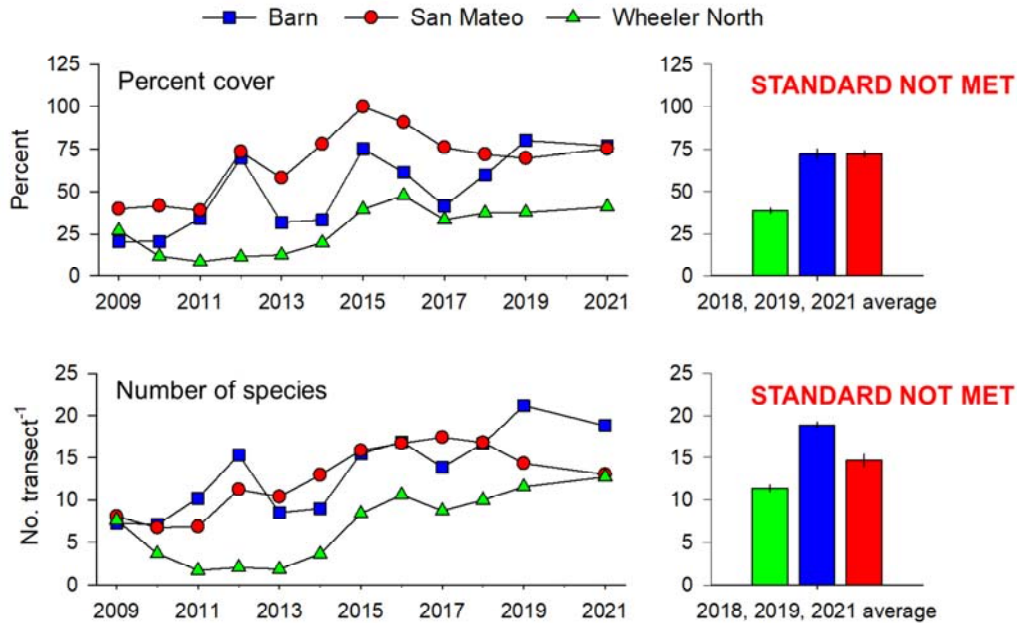


- Shown here are the 11 relative performance standards that are used to judge the performance of Wheeler North Reef
- Standards 1-5 pertain to the benthic community of macroalgae and invertebrates
- Standards 6-10 pertain to reef fishes
- Standard 11 integrates the benthic community of macroalgae and invertebrates with reef fishes by examining the extent to which the benthic community supplies food for reef fishes
- What follows next are the results of the 2021 performance monitoring for these 11 standards



## Performance Standards: Macroalgae

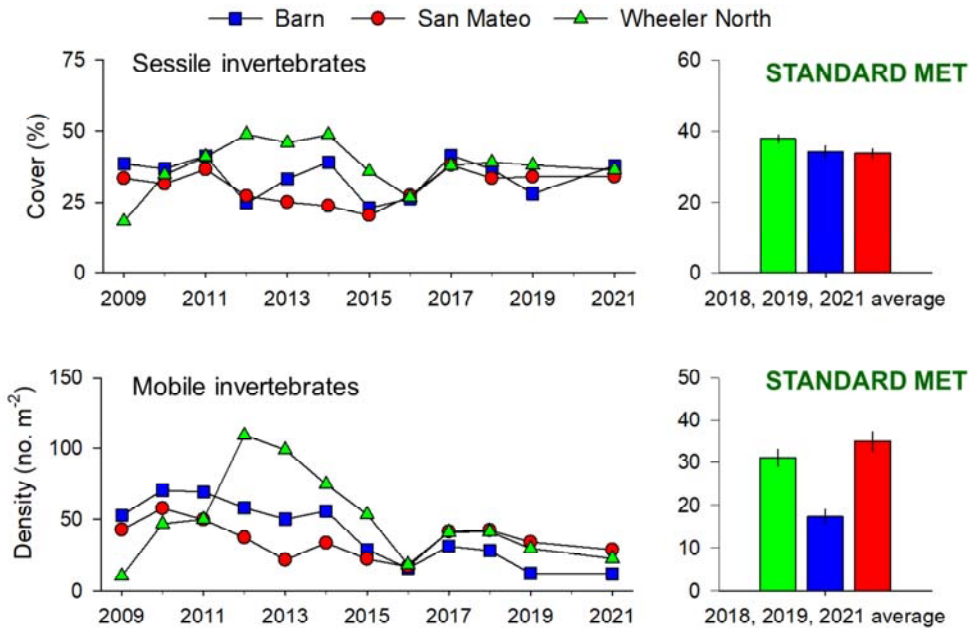
*The percent cover and number of species of algae must be similar to natural reefs within the region*



- In the slides that follow different colors are used for the different reefs
  - Blue and red represent the reference reefs at Barn and San Mateo respectively
  - and green represents Wheeler North Reef
- In each slide the annual time series since 2009 is plotted on the left and the average for 2018, 2019 and 2021 is plotted on the right.
- This slide shows the mean (+/- SE) percent of the bottom covered by macroalgae at the three reefs in the top two graphs and the mean number of species of macroalgae in the bottom two graphs
- The annual time series shows that percent cover and number of species of macroalgae at Wheeler North Reef has been increasing over time, but has nonetheless been consistently lower than that of nearby natural reefs
- As such Wheeler North Reef did not meet either of these performance standards in 2021.

## Performance Standards: Invertebrates

*The percent cover of sessile invertebrates and the density of mobile invertebrates must be similar to natural reefs within the region*

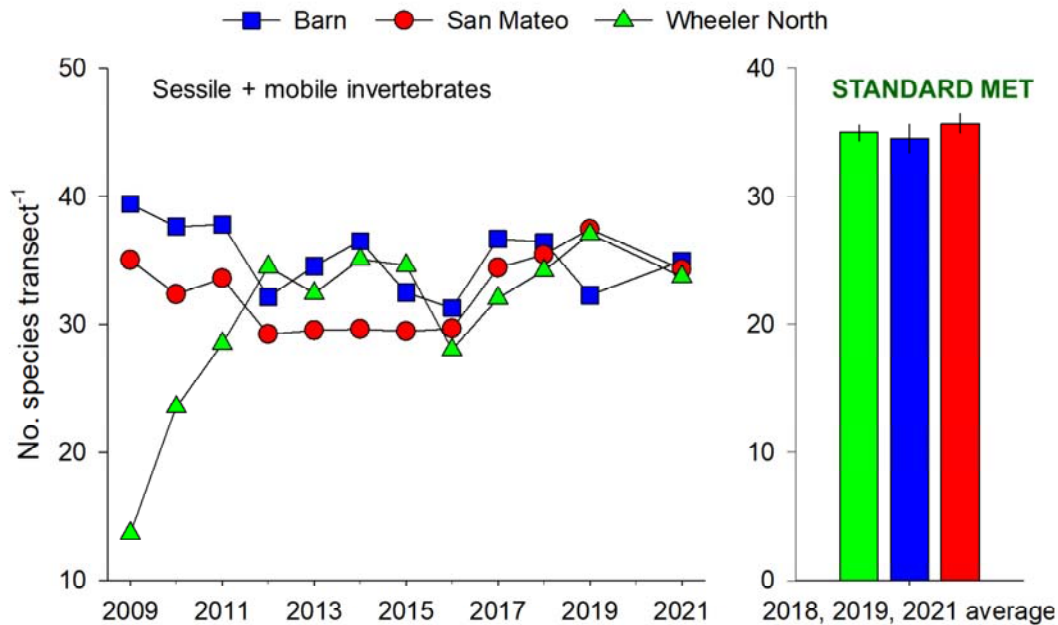


- Plotted here are data collected at Wheeler North, Barn and San Mateo reefs on the percent of the bottom covered by sessile invertebrates (top two graphs) and the abundance of mobile invertebrates (bottom two graphs)
- Sessile invertebrates compete for space on the reef with macroalgae, but instead of producing their own food via photosynthesis they feed by filtering plankton from the water column
- In contrast, mobile invertebrates consist of a wide range of grazers and predators that feed on reef associated macroalgae, sessile invertebrates and other mobile invertebrates.
- The monitoring data show that except for the first year in the time series, the abundance of sessile and mobile invertebrates at Wheeler North Reef have consistently been within or above the range of nearby natural reefs
- Wheeler North Reef met both of these performance standards in 2021.



## Performance Standards: Invertebrates

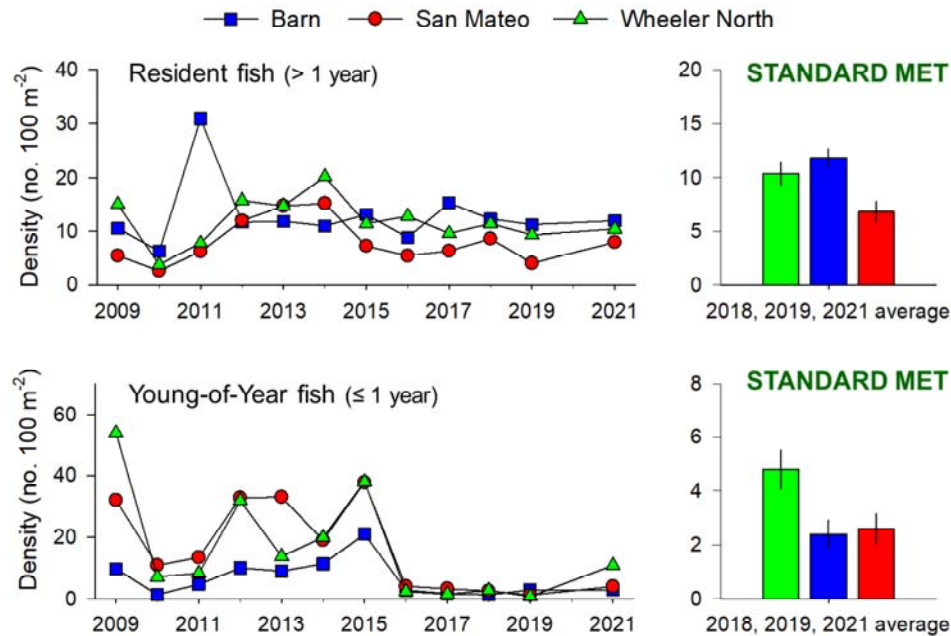
*The number of species of invertebrates must be similar to natural reefs within the region*



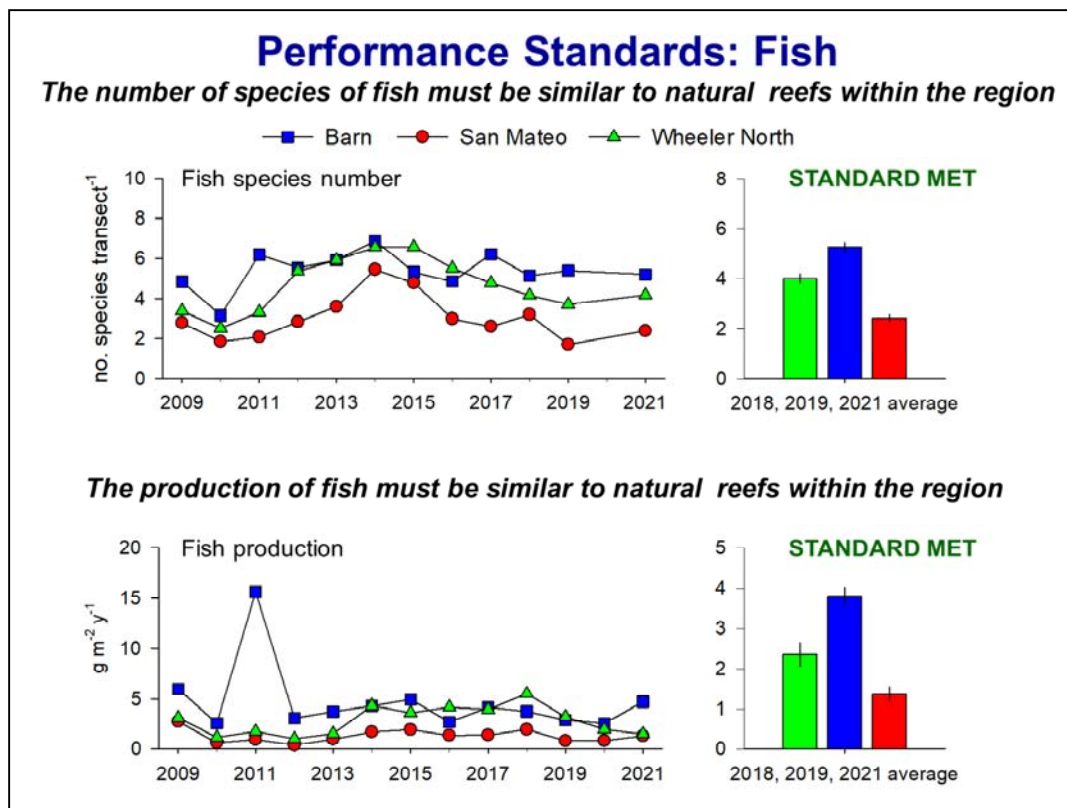
- This graph shows the mean (+/- SE) number of species of all invertebrates (sessile + mobile) per transect at Wheeler North, Barn and San Mateo reefs
- Relatively few species of invertebrates inhabited Wheeler North Reef during the first couple of years of its existence
- Since 2012 the number of species of reef invertebrates at Wheeler North Reef has been much more similar to that of nearby natural reefs
- Wheeler North Reef has consistently met this performance standard since 2012, including in 2021

## Performance Standards: Fish

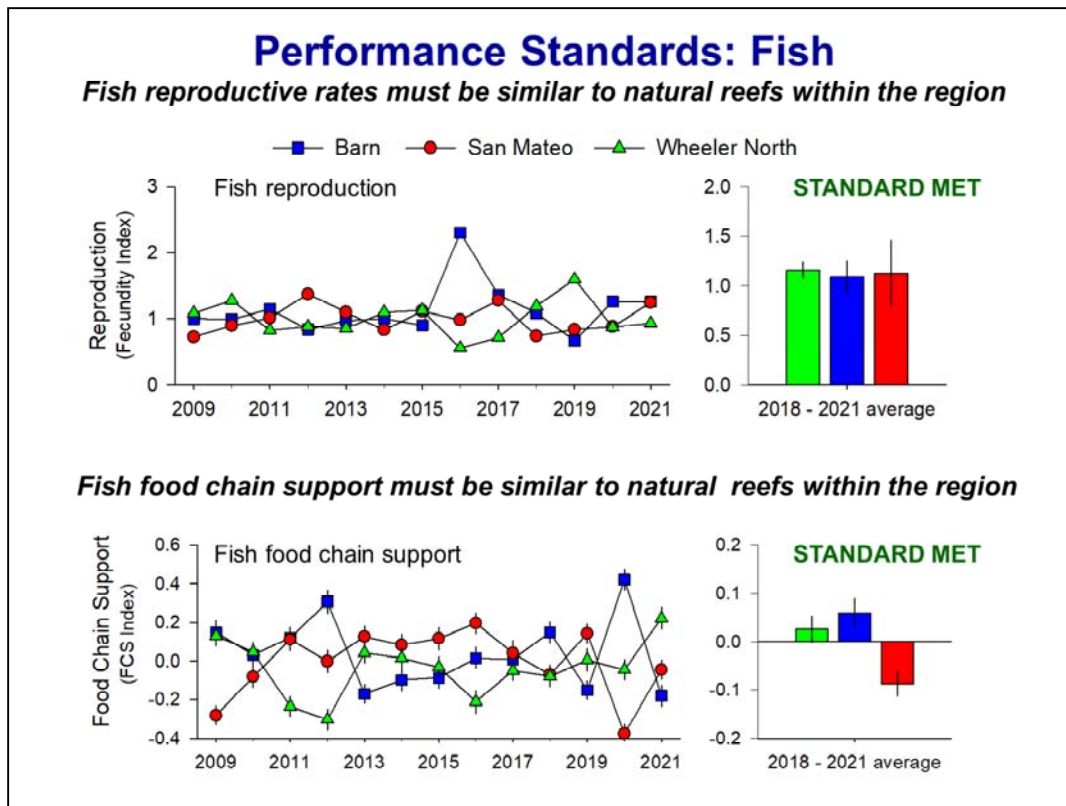
*The abundances of resident and young-of-year fish must be similar to natural reefs within the region*



- Plotted here are data collected at Wheeler North, Barn and San Mateo reefs on the mean ( $\pm$  SE) density of older resident fish (top 2 graphs) and newly recruited Young-of-Year reef fish (bottom 2 graphs).
- Resident fish are defined as fish > 1 year in age as determined by their size, while Young-of-Year fish are smaller fish that were born in the current year
- Densities of resident fish at all three reefs have remained relatively stable through the time series, especially since 2015.
- The major exception to this was in 2011 at Barn when several large schools of seniorita were observed causing a large spike in the mean density
- Densities of Young-of-Year fish fluctuated sporadically at all three reefs until 2016 when they declined dramatically. They have remained low since then, with a slight increase at Wheeler North Reef in 2021
- Importantly, the densities of resident and YOY fish at Wheeler North Reef have consistently been within or above the range of nearby natural reefs
- Consequently, Wheeler North Reef met both of these performance standards in 2021



- This slide shows the mean ( $\pm$  SE) number of species of reef fish per transect at the Wheeler North, Barn and San Mateo reefs.
- The number of species of fish at Wheeler North Reef has consistently been within or above the range of nearby natural reefs as shown by the time series on the left
- This resulted in a 3-year average at Wheeler North Reef in 2021 that was intermediate between the two reference reefs, which means Wheeler North Reef met this performance standard in 2021
- The bottom two graphs show the mean annual production of reef fish biomass on the left and the mean 3-year average on the right
- Fish production is the amount of fish biomass produced per unit area in a given year and it takes into account both somatic and gonadal growth
- Somatic growth is estimated from the width of annual rings in the ear bones of fish, while gonadal growth is measured as the production of tissue associated with reproduction, which can be quite large
- We measure somatic and gonadal growth in five indicator species: blacksmith, señorita, black perch, the California sheephead and kelp bass
- These species were chosen because they are among the most common species of fish in the kelp forest and they represent different feeding guilds that use the reef in different ways
- Blacksmith eat plankton during the day and seek shelter on the reef at night, señorita eat plankton and small invertebrates on the reef, black perch feed on small invertebrates that live on or near the bottom, sheephead feed on larger invertebrates on the bottom, and kelp bass primarily feed on other species of fish
- Fish production has been relatively constant over the time series ranging from  $\sim 1$ -  $5$  g per  $m^2$  of bottom per year
- The exception again being at Barn in 2011 when high production by all five species at this site caused production to spike to  $\sim 15$  g per  $m^2$  per year
- Throughout the time series fish production at Wheeler North Reef has consistently been within or above the range of the two reference reefs
- In 2021 its average for 2018, 2019 and 2021 was in between that of San Mateo and Barn, hence it met this performance standard



- Plotted in the top two graphs are indices of female fecundity, which we use as a measure of reef fish reproduction
- The fecundity index represents a mean of the annual egg production scaled to female size averaged over three indicator species: kelp bass, California sheephead and senorita
- The mean fecundity index at Wheeler North Reef has been largely similar to that at nearby natural reefs over the 13 years of monitoring
- In 2021 the 4-y running average of the fecundity index was higher at Wheeler North Reef than the two reference reefs, despite Wheeler North Reef having the lowest value of the three reefs in 2021
- As a result of its high 4-y running average Wheeler North Reef met this standard in 2021
- There is also a performance standard that requires the benthic community of Wheeler North Reef to provide food for the fishes that feed on the reef at a level that is similar to that provided by natural reefs
- We evaluate this performance standard by measuring the weight of the food in the guts of two common species of fish that feed on the bottom: black perch and the California sheephead
- We use this information to calculate an index of food chain support that is scaled to the weight of the fish
- The food chain support (FCS) index at all three reefs has fluctuated inconsistently over time
- The value of the index in 2021 and the average of the last 4 years was higher at Wheeler North Reef than the two reference reefs
- Consequently, Wheeler North Reef met the FCS standard in 2021

## **Relative Performance Standards**

*(must be similar to natural reference reefs)*

### **Evaluation Criteria**

Wheeler North Reef (WNR) must meet as many relative standards as the lowest performing reference reef in a given year for that year to count towards mitigation credit.

### **Rationale**

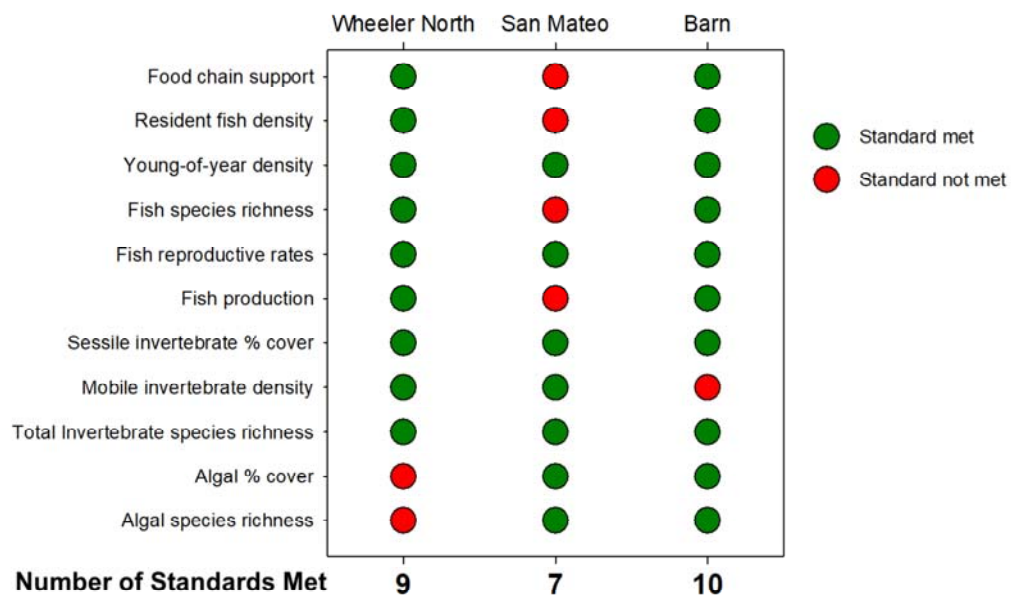
Requiring WNR to meet at least as many relative standards as the reference reefs achieves the desired goal of WNR being similar to natural reefs without requiring it to consistently outperform them.

### **Method of Evaluation**

WNR and the reference reefs are evaluated with respect to each other to determine whether they meet each relative standard and the total number of relative standards met by each reef is tallied and compared.

- Because natural kelp forests vary greatly over time in their species composition and abundance, it is likely that they too would not consistently meet all the relative performance standards in a given year
- Therefore, to avoid requiring Wheeler North Reef to perform better than the reference reefs, Wheeler North Reef is required to meet only as many of the relative standards as the lowest performing reference reef in a given year for that year to count towards mitigation credit
- This achieves the desired goal of Wheeler North Reef being similar to natural reefs without requiring it to consistently outperform them
- The method involves evaluating the performance of the three reefs relative to each other to determine whether they meet each relative standard
- The total number of relative standards met by each reef is then tallied and compared

## In 2021 the Wheeler North Reef met more relative performance standards than the lowest performing reference reef



***Wheeler North Reef met the mitigation requirement for the relative performance standards in 2021***

- This slide summarizes the number of relative standards met by Wheeler North Reef and the two reference reefs (San Mateo and Barn) in 2021
- The monitoring results show that Wheeler North Reef met 9 of the 11 relative standards in 2021, which was one fewer than the number of standards met by Barn and 2 greater than that met by San Mateo, the lower performing of the two reference reefs
- Based on these results we conclude that the ecological resources and functions provided by Wheeler North Reef in 2021 were *similar* to those provided by nearby natural reefs
- Therefore, Wheeler North Reef met the collective mitigation requirement for the relative performance standards in 2021



## Absolute Performance Standards that must be met every year for the Wheeler North Reef to receive mitigation credit



*At least 90 percent of the exposed hard substrate must remain available for attachment by reef biota*



The important functions of the reef shall not be impaired by undesirable or invasive benthic species

### **Method of evaluation**

The evaluation of each standard is based on the value measured for the current year, or the 4-year running average (calculated from the current year and the previous three years), *whichever is higher*.

There are two absolute performance standards that Wheeler North Reef must meet each year in order for it to receive mitigation credit:

1. The performance standard for hard substrate requires at least 90% of the exposed rock initially present on the Phase 1 and 2 Wheeler North Reef remain available for the attachment by reef biota
2. The performance standard for invasive species requires that Wheeler North Reef shall not be impaired by undesirable or invasive benthic species

The evaluation of each of these standards is based on the value measured at the Phase 1 and 2 Wheeler North Reef for the current year, or the 4-year running average (calculated from the current year and the previous three years), which ever is higher

## Method used to measure the Area of Hard Substrate

1. Measure footprint area ( $A$ ) of Wheeler North Reef (Phases I + 2) in sonar surveys
2. Measure percent cover of exposed rock ( $P$ )
3. Calculate area of exposed rock as  $A \times P$
4. Compare area of exposed rock to that measured shortly after reef construction in 2009 to determine whether 90% or more is still available for reef biota



### 9 Substrate categories:

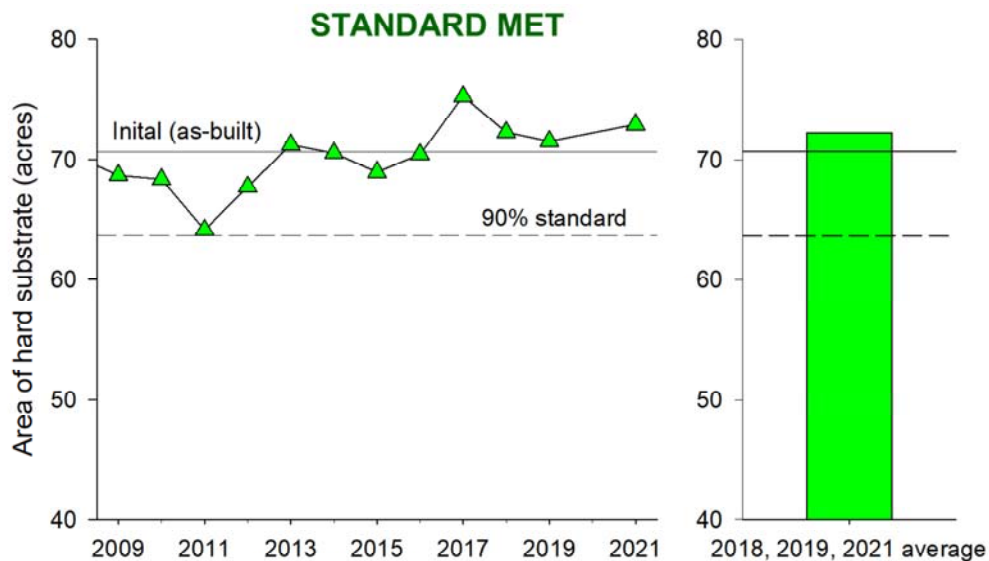
**Bedrock**  
**Large boulder** ( $\geq 100$  cm)  
**Medium boulder** ( $\geq 50$ cm &  $<100$ cm)  
**Small boulder** ( $\geq 26$ cm and  $<50$ cm)  
**Cobble** ( $\geq 7$ cm and  $\leq 25$ cm)  
**Pebble** ( $\geq 2$ mm and  $< 7$ cm)  
**Sand** ( $< 2$ mm)  
**Shell hash**  
**Mudstone**

The performance standard for hard substrate is evaluated in the following way:

- Multi-beam sonar used to measure the combined footprint area ( $A$ ) of Phase 1 and 2 of Wheeler North Reef once every 5 years
- Divers estimate the percent cover of exposed rock ( $P$ ) in five  $1 \text{ m}^2$  quadrats on the 82 transects distributed across Phase 1 and 2 of Wheeler North Reef.
- The product  $A \times P$  is the estimate of the area of exposed hard substrate
- We compare this estimate to that obtained immediately following construction of Phase 2 of Wheeler North Reef
- The SONGS coastal development permit requires that this amount not fall below 90% of what was available immediately after the reef was constructed
- Divers collect percent cover data for nine different types of bottom substrate
- The five categories of bottom substrates outlined in the green box are those that constitute hard substrate in our analyses

## Performance Standard: Hard Substrate

*At least 90 percent of the exposed hard substrate must remain available for attachment by reef biota*



- Plotted here is an annual time series of the total area of exposed hard substrate at Wheeler North Reef (left) and the average for 2018, 2019 and 2021 (right)
- The annual time series shows that at least 90% of the initial area of exposed hard substrate on the Phase 1 and 2 Wheeler North Reef has remained available every year since the Phase 2 reef was constructed
- Annual values greater than the initial as-built in some years likely reflect scouring and/or redistribution of reef material that resulted in an increase in the total area of exposed hard substrate
- Wheeler North Reef met this performance standard in 2021 as both the annual value and the average of 2018, 2019 and 2021 were greater than the as-built condition and thus exceeded the 90% threshold.

## Performance Standard: Undesirable & Invasive Species

The important functions of the reef shall not be impaired by undesirable or invasive benthic species



Sea fan aggregation



Sea urchin aggregation



*Caulerpa prolifera*



*Sargassum horneri*

Undesirable and invasive species that are of potential concern include:

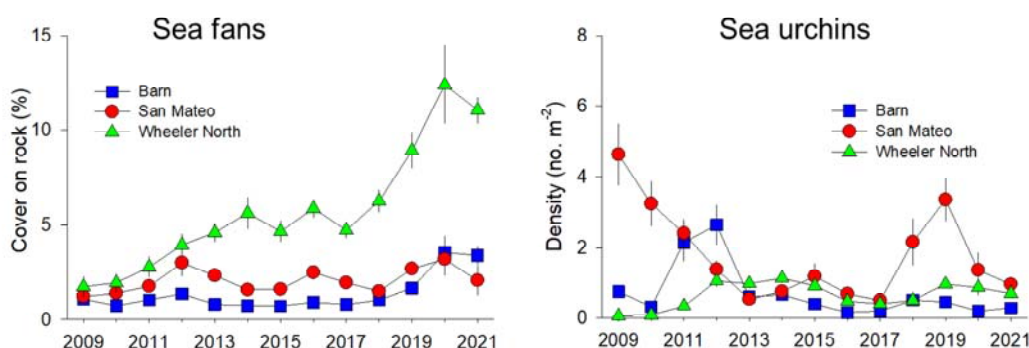
- High density sea fans
- High density sea urchins
- Non-native algae (e.g., *Caulerpa*, and *Sargassum*)

**Primary production by giant kelp and secondary production of reef fishes are important reef functions used to evaluate this performance standard**

- The other absolute performance standard that must be met every year for Wheeler North Reef to receive mitigation credit requires that its important ecological functions not be impaired by undesirable or invasive benthic species
- Native species can become “undesirable” if they become so abundant that they impair important functions of the reef
- Two examples of this are dense aggregations of sea fans that can monopolize space and exclude other species including giant kelp, and high densities of sea urchins that can over graze the bottom and create large deforested areas commonly called “sea urchin barrens”
- Invasive species are non-native species that become abundant and displace native species or otherwise harm important reef attributes and functions.
- Two non-native species that are known to be invasive in southern CA are the green alga *Caulerpa prolifera* and the brown alga *Sargassum horneri*
- Primary production by macroalgae and secondary production by reef fishes are two important functions of reefs
- We are using data on the density of giant kelp fronds to estimate the net primary production of giant kelp and data on the growth, reproduction and biomass of 5 indicator species of reef fish to estimate the secondary production of reef fish



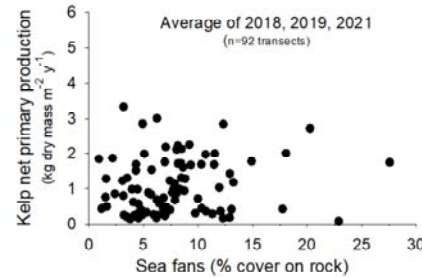
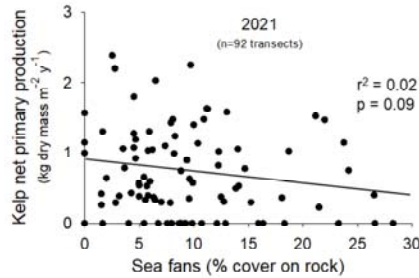
## Performance Standard: Undesirable Species



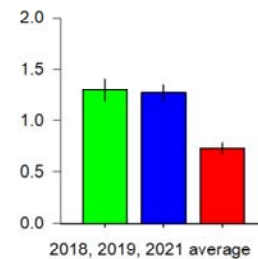
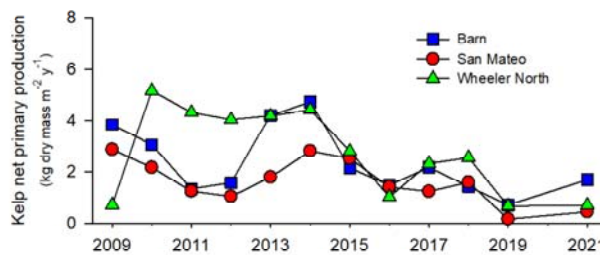
- The percent cover of sea fans is increasing disproportionately more at Wheeler North Reef compared to the reference reefs
  - *potential concern for impairment of important reef functions by sea fans*
- The density of sea urchins at Wheeler North Reef has been consistently low ( $< 1 \text{ m}^{-2}$ )
  - *little concern at this time for the impairment of important reef functions by sea urchins*

- The percent cover of sea fans has been increasing on all three reefs, but disproportionately so at Wheeler North Reef, raising a potential concern that sea fans could impair important reef functions
- In contrast, the average density of sea urchins at Wheeler North Reef has remained relative stable at near 1 per  $\text{m}^2$  since 2012.
- This low density is far below the threshold of 20-30 urchins per  $\text{m}^2$  that is known to convert kelp forested reefs to barren areas
- Consequently, there is little concern that sea urchins are impairing the important functions of Wheeler North Reef at this time
- Based on these patterns we focused our attention of “undesirable species” on sea fans

## Are sea fans impairing kelp primary production?



- Weak negative correlation between sea fan cover and kelp production in 2021 suggest some impairment of kelp production by sea fans may be occurring
- No correlation when data are averaged over 2018, 2019 and 2021



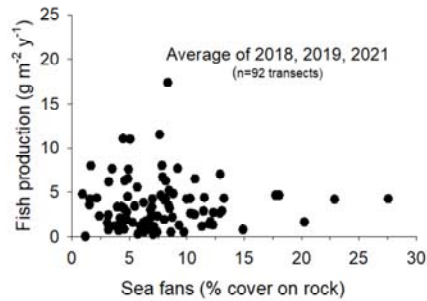
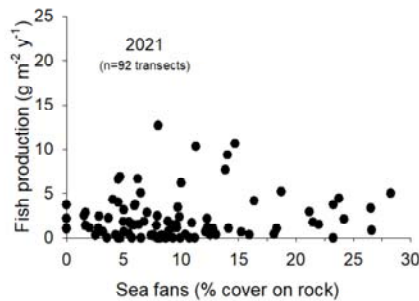
- Kelp production at Wheeler North Reef was not impaired relative to reference sites

**No compelling evidence that sea fans impaired kelp primary production**

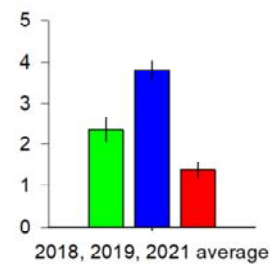
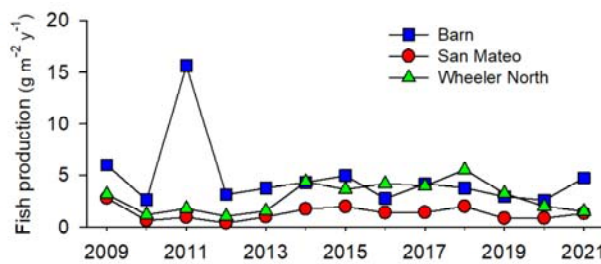
- One way to examine whether sea fans are impairing kelp primary production at Wheeler North Reef is to examine the relationship between the kelp primary production and the percentage of rock that is covered by sea fans
- Shown here are these relationships for 2021 on the left and for the average of 2018, 2019 and 2021 on the right
- The data points in these graphs represent the 92 transects sampled on the Phase 1 and Phase 2 reefs
- The net primary production (NPP) of giant kelp is estimated from the density of giant kelp fronds based on quantitative relationships between NPP and frond density that have been developed by the Santa Barbara Coastal Long Term Ecological Research program (<https://sbclter.msi.ucsb.edu/>)
- The data collected in 2021 suggest a weak negative correlation between sea fan cover and kelp primary production, which could be indicative of some minor impairment of kelp production by sea fans
- By contrast, there is no indication of any such relationship using data averaged over 2018, 2019 and 2021
- Another means of determining whether kelp primary production at Wheeler North Reef is impaired is to compare its kelp primary production to that at the reference reefs
- When we do this we find that kelp primary production at Wheeler North Reef has been within or above the range of the two reference reefs since 2010 and this is reflected in the data shown for the 2021 in the time series graph on the left and in the graph of the recent 3-year average on the right
- Hence, when all data are considered we conclude that there is no compelling evidence that sea fans impaired kelp primary production at Wheeler North Reef in 2021



## Are sea fans impairing reef fish production?



- No correlation between sea fan cover and secondary production of reef fish for 2021 or for the average of 2018, 2019 and 2021



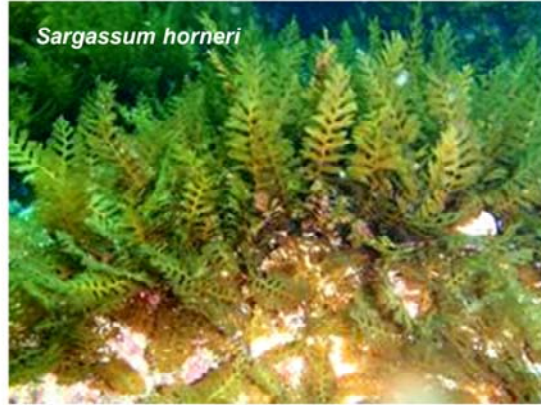
- Reef fish production at Wheeler North Reef was not impaired relative to reference sites

**No evidence that sea fans impaired reef fish production**

- We can use the same types of analyses to determine whether sea fans are impairing the secondary production of reef fish at Wheeler North Reef
- The top two graphs show no relationship between fish production and the percent of the reef covered by sea fans in either 2021 or the 3-y average of 2018, 2019 and 2021.
- Furthermore, as shown earlier fish production at Wheeler North Reef has been consistently within the range of the two reference reefs suggesting that it is not impaired relative to natural reefs
- Hence there is no evidence that sea fans are impairing the secondary production of reef fish at Wheeler North Reef

## Performance Standard: Invasive Species

### Non-native macroalgae



***No non-native benthic macroalgae were observed at Wheeler North Reef in 2021***

**No evidence that invasive, non-native benthic species impaired important ecological functions of Wheeler North Reef**

- We did not record any non-native benthic macroalgae at Wheeler North Reef in our 92 transects in 2021
- Hence there is no evidence that invasive non-native species have impaired important ecological functions at Wheeler North Reef

## **Performance Standard: Undesirable & Invasive Species**

**The important functions of the reef shall not be impaired by undesirable or invasive benthic species**

### **Conclusion:**

- No compelling evidence that *undesirable* native species or *invasive* non-native species adversely affected the important functions of Wheeler North Reef
  - We will continue to monitor the abundance of sea fans and their potential impact on the primary production of giant kelp

**STANDARD MET**

- Based on correlative analyses involving sea fans and sea urchins and the lack of observations of non-native invasive macroalgae at Wheeler North Reef we conclude that there is no evidence that undesirable or invasive species adversely affected the important ecological functions of Wheeler North Reef in 2021
- Therefore Wheeler North Reef met the performance standard for undesirable and invasive species in 2021

## **Absolute Performance Standards that accumulate mitigation credit on an annual basis**



**Giant kelp**

*The artificial reef(s) shall sustain 150 acres of medium-to-high density giant kelp*



**Fish standing stock**

*The standing stock of fish at the mitigation reef shall be at least 28 tons*

### **Method of evaluation**

- The annual standing stock of fish and acreage of giant kelp at Wheeler North Reef are measured each year and summed over time until they reach a cumulative total equivalent to the annual target x the number of years of SONGS operations (= 32 years)
- Accumulation of kelp acreage and fish standing stock began in 2019

Unlike the absolute performance standards for hard substrate and invasive species that must be met each year, the absolute standards pertaining to giant kelp area and fish standing stock are evaluated on a cumulative basis and Wheeler North Reef receives partial credit for these standards each year

1. The performance standard for giant kelp is based on the intent that Wheeler North Reef sustain 150 acres of medium-to-high density giant kelp for a period of time equivalent to the operating life of SONGS
  2. Similarly, the performance standard for fish standing stock is based on the intent that Wheeler North Reef sustain a fish standing stock of at least 28 tons for a period of time equivalent to the operating life of SONGS
- Mitigation credit for these two performance standards is summed over time until the accumulated credit for each performance standard reaches a total value equivalent to the annual target (which is 150 acres for kelp and 28 tons for fish) x the number of years of SONGS operations which was defined by the CCC to be 32 years
  - The CCC determined that the accumulation of kelp acreage and fish standing stock would begin in 2019

## Methods used to estimate the area of giant kelp

Divers record the density of adult giant kelp in a fixed 100 m<sup>2</sup> area of each transect at Wheeler North Reef (n= 149 transects)



**Acres of medium-to-high density adult kelp =  $P \times 373$  acres**

**where:**

$P$  = proportion of transects with > 4 adult plants, and

373 = footprint area of Wheeler North Reef in acres based on the most recent sonar survey

medium-to-high density is defined as > 4 adults per 100 m<sup>2</sup>

adults are defined as individuals with 8 or more fronds

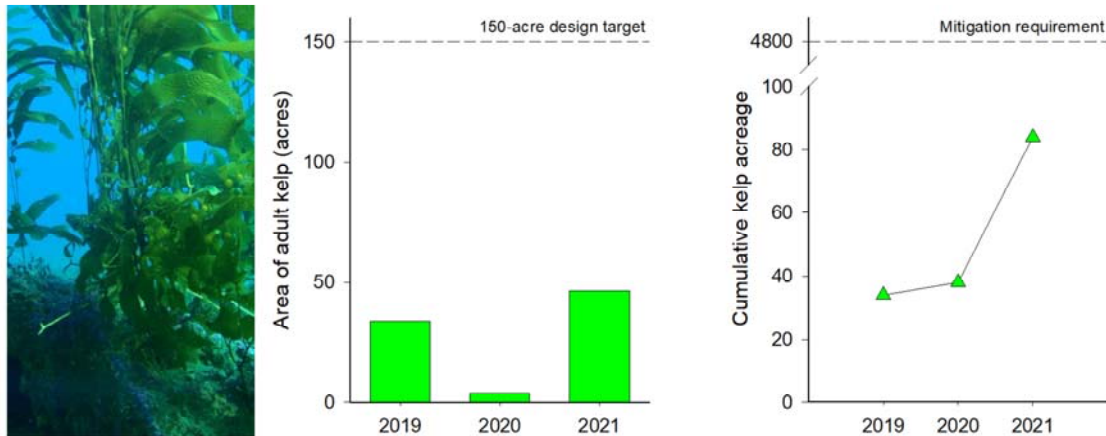
- The performance standard for giant kelp is evaluated by measuring the density of giant kelp in the fixed transects across all three phases of Wheeler North Reef
- Using these data we calculate the proportion of transects at Wheeler North Reef that have adult kelp densities > 4 plants per 100 m<sup>2</sup>
- This proportion is multiplied by 373 acres (= the combined footprint area of Phases 1, 2 and 3 of Wheeler North Reef measured in the most recent sonar survey) to obtain the total acreage of adult kelp at Wheeler North Reef.



## Performance Standard: Giant Kelp

**Reef design:** Average 150 acres of medium-to-high density adult giant kelp for a minimum of 32 years

Medium-to-high density is defined as  $> 4$  adults  $100 \text{ m}^2$ ; Adults are defined as individuals having at least 8 fronds



**Wheeler North Reef earned mitigation credit for 47 acres of medium-to-high density adult giant kelp in 2021 resulting in a cumulative total of 84 acres of adult giant kelp**

- This graph shows the area of medium-to-high density adult giant kelp supported by Wheeler North Reef in 2019, 2020 and 2021
  - Medium-to-high density is defined as  $> 4$  adults  $100 \text{ m}^2$
  - Adults are defined as individuals having at least 8 fronds
- In 2021 Wheeler North Reef earned 47 acres of credit for sustaining medium-to-high density giant kelp, which is more than it supported in 2019 or 2020
- This value is greater than that recorded in 2019 or 2020, but nonetheless is substantially below the 150-acre design target
- When added to the previous two years, Wheeler North Reef has accumulated a total of 84 acres of medium-to-high density adult giant kelp. It's worth noting that the area of kelp on Wheeler North Reef in recent years has been far below that of prior years when every acre of the reef supported  $> 4$  adult plants /  $100 \text{ m}^2$



## Methods used to evaluate the standing stock of reef fish

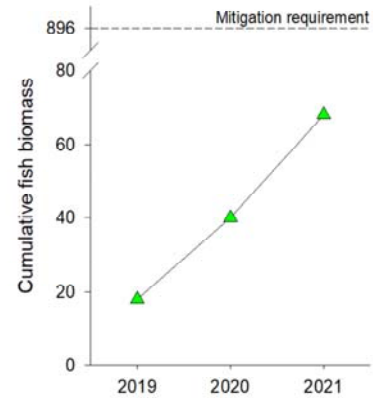
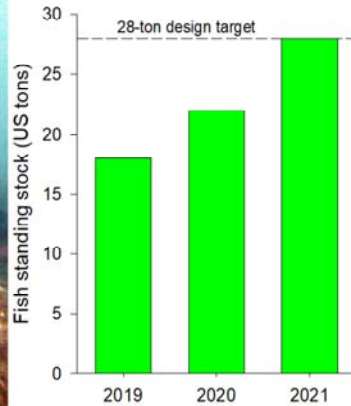


1. Apply species-specific length-weight relationships to fish density and size data collected by divers to calculate the average biomass density ( $\text{g m}^{-2}$  reef) of all fish near the bottom from all transects.
2. Scale up estimates of fish biomass  $\text{m}^{-2}$  to the footprint area of Wheeler North Reef (= 373 acres) to obtain an estimate of the standing stock of fish near the bottom at Wheeler North Reef.

- Data on fish density and length collected from the 149 transects distributed across the 3 phases of Wheeler North Reef are used to calculate the total standing stock of fish near the bottom on the reef to determine whether it supports 28 tons of reef fish
- The weights of the fish counted are estimated from known relationships between length and weight for each species
- The weights of all fish counted on a transect are summed to obtain an estimate of fish biomass density for each transect in units of grams per  $\text{m}^2$  of reef
- The biomass density of fish is averaged over all transects in a polygon and multiplied by area of the polygon to obtain an estimate of the biomass of fish in each polygon
- The biomass of fish in each polygon is summed to obtain an estimate of the standing stock of fish near the bottom on the 373-acre Wheeler North Reef

## Performance Standard: Fish Standing Stock

**Reef design:** support a standing stock of fish that averages at least 28 tons for 32 years



**Wheeler North Reef earned mitigation credit for 28 tons of fish standing stock in 2021 resulting in a cumulative total of 68 tons of fish standing stock**

- Shown here is annual standing stock of reef fish on Wheeler North Reef in 2019, 2020 and 2021
- Wheeler North Reef earned 28 tons of credit for its fish standing stock in 2021, which equaled the 28-ton design target and exceeded the amounts earned in 2019 and 2020
- Wheeler North Reef has accumulated mitigation credit for 68 tons of fish standing stock since 2019, which is still far below the mitigation requirement of 896 tons

## **SONGS Reef Mitigation Credit**

### ***Relative performance standards & Absolute performance standards for hard substrate and invasive & undesirable species***

- One year of mitigation credit is given for each year that Wheeler North Reef meets all of these performance standards
- Fulfillment of the mitigation requirement occurs when the number of years of mitigation credit accrued by the Wheeler North Reef equals the total years of operation of SONGS Units 2 & 3 (= 32 years)

### ***Absolute performance standards for giant kelp area and fish standing stock***

- Each performance standard is evaluated independently.
- Fulfillment of these mitigation requirements occur when the total accrued acres of kelp or tons of fish equal the targeted annual value (= 150 acres of kelp or 28 tons of fish) x the total years of operation of SONGS Units 2 & 3 (= 32 years)

- The goal of the SONGS reef mitigation project is to replace the kelp forest resources that were lost due to the operations of SONGS Units 2 & 3, which lasted for 32 years
- One year of mitigation credit is given for each year that Wheeler North Reef meets the collective group of relative performance standards and the absolute standards pertaining to hard substrate and invasive species
- Fulfillment of the mitigation requirement for these performance standards occurs when the number of years of mitigation credit accrued by Wheeler North Reef equals the total years of operation of SONGS Units 2 & 3 (= 32 years)
- Unlike the other performance standards the absolute performance standards for giant kelp area and fish standing stock accrue mitigation credit over time independently of the other performance standards
- Fulfillment of the mitigation requirements for these performance standards occurs when the total amount of credit accrued equals the targeted annual value (= 150 acres in the case of giant kelp and 28 tons in the case of fish standing stock) x the total years of operation of SONGS Units 2 & 3 (= 32 years)

## Wheeler North Reef

### Summary of earned mitigation credit

|  | <u>2021 status</u> |
|--|--------------------|
| Relative performance standards         | Pass               |
| Hard substrate                         | Pass               |
| Undesirable and Invasive species       | Pass               |
| Years of credit earned in 2021         | 1                  |
| Total number of years of credit earned | 3                  |
| Number of years of credit required     | 32                 |
| Number of years of credit still needed | 29                 |

|                     | 2021<br>credit | Cumulative<br>credit | Credit<br>required | Credit<br>needed |
|---------------------|----------------|----------------------|--------------------|------------------|
| Giant kelp area     | 47 acres       | 84 acres             | 4800 acres         | 4716 acres       |
| Fish standing stock | 28 tons        | 68 tons              | 896 tons           | 828 tons         |

- Shown here is a summary of project compliance for the SONGS reef mitigation project
- In 2021 Wheeler North Reef earned 1 year of credit for meeting the collective group of relative standards and the absolute standards for hard substrate and invasive species
- It has earned a total of 3 years of mitigation credit for these performance standards and needs another 29 years of credit for this mitigation requirement to be met
- In 2021 Wheeler North Reef earned credit for 47 acres of giant kelp for a cumulative credit of 84 of the 4,800 acres of giant kelp required for the giant kelp performance standard
- An additional 4,716 kelp acres is needed before the mitigation requirement for the giant kelp performance standard is met
- In 2021 Wheeler North Reef earned credit for 28 tons of fish standing stock for a cumulative credit of 68 tons
- It needs to earn an additional 826 fish tons of mitigation credit before the mitigation requirement for the fish standing stock performance standard is met

## **Annual Public Workshop**

**San Onofre Nuclear Generating Station Artificial Reef Mitigation Project**  
**Monday, April 4, 2022**

### **Agenda**

- |                    |  |
|--------------------|--|
| <b>1:30 – 1:40</b> | <b>Introduction to SONGS reef mitigation –<i>Dan Reed, UCSB</i></b>  |
| <b>1:40 – 2:20</b> | <b>Results from the 2021 performance monitoring of the Wheeler North Reef – <i>Steve Schroeter, UCSB</i></b> |
| <b>2:20 - 2:40</b> | <b>Questions and comments on performance monitoring results</b>  |
| <b>2:40 – 3:10</b> | <b>Temporal and spatial patterns of species abundance on Wheeler North Reef – <i>Kat Beheshti, UCSB</i></b>  |
| <b>3:10 - ??</b>   | <b>Questions and comments and general discussion</b>   |



For more information go to: <http://marinemitigation.msi.ucsb.edu/>